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Application of the Telephone To Commercial Measurements

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APPLICATION OF THE TELEPHONE TO COMMERCIAL MEASUREMENTS

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Carl Kent Brydges and William Thomas Burnett

ENTITLED Application of the Telephone to Commercial Measurements

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Electrical Engineering.

Morgan Brooks

HEAD OF DEPARTMENT OF Electrical Engineering.

PREFACE.

The D'Arsonval type of galvanometer has long been used in making commercial tests in resistance and capacity measurements, and is probably as sensitive an instrument as will ever be invented for this purpose. The galvanometer is, however, a delicate instrument, requiring the best and most careful handling, and a level place on which to set it while in use. Portable galvanometers, in the true sense of the word, are not made- that is, those that can be used without a solid pier for support. For these reasons, measurements must be made with much care and with delicate and costly instruments, in order to obtain correct results.

Some time ago, experiments, using telephone receivers in place of a galvanometer for measuring non-inductive resistances, were used. These were quite successful for a certain range of resistances, corresponding to the resistance in the winding of the receiver. These results showed that there was a great possibility for the use of the telephone receiver in this work. In accordance with this belief, the authors decided to try experiments, not only with the telephone receivers, but with a set of transformer or induction coils as well.

The authors wish to express their thanks to Professor Brooks for his many helpful suggestions during the course of this work.

W. T. Burnett.   C. K. Brydges.

OBJECT:

To test the sensitiveness of the telephone and transformer coils in the measurement of resistance and capacity, and to determine its adaptability to tests where approximate results are sufficient.

DISCUSSION:

We will now explain the principle and construction of the transformer coils. In the first place, the telephone method is adapted only for zero method. By use of the telephone receiver the zero position is determined as lying between slight sounds on either side of zero point. If in the receiver circuit a transformer is placed, its secondary being wound to the same number of turns as receiver, its primary will take the place of a galvanometer, and any current, or rather, any change of current, will be readily recognizable by the receiver.

Telephone receivers with coils of low, medium, and high resistance might be used, but it is more convenient to have primary of transformer divided into several sections; or it is better yet if there are several different primaries which are interchangeable with secondary. If this be the case, the range of resistance that can be measured is almost unlimited.

To begin with, the transformers were built and then mounted upon a baseboard and fitted with proper binding-posts, paper covering, etc. The secondary was wound on a spool

having a winding space 3" long and a width, measured radially on spool, of 3/16". The spool was 5/8" in diameter and 3-3/4" long. A 1/4" hole ran through the spool lengthwise. This core space was filled with soft iron wire. The secondary was wound with 1750 turns of #36 silk--covered copper wire. Five primaries of different sized wire were wound for the transformer. These spools were 3-3/4" long and 2-1/2" wide at ends. The winding space was 3" long, and, measured radially, was 7/8" in width. The hole through center was of such size as to admit the secondary being placed therein. This allowed the secondary to be used with anyone of the primaries and to be easily changed from one to the other. One of the primaries was wound with 1750 turns of #36 silk-covered copper wire, making, with the secondary of #36 wire, a one to one transformer. Another coil was wound with #38 wire, having enough turns to make about the same weight of wire as on the other primaries. In fact, this was the case in all the primaries, to have about the same weight of wire in windings. The three remaining coils were wound with #24, #18, and #12 wire, giving three more different ratios of transformation.

The method of measuring resistance was that of Wheatstone Bridge principle, and, in order to use transformer with this method, a pulsating or an alternating current must be used.

This alternating current was obtained in the following manner: A telephone transmitter induction coil was mounted

upon same base, as a make-and-brake device, which was the vibrator of an electric bell. The primary of the induction coil was connected in the circuit of the vibrator. The secondary was connected to "battery" binding posts of Wheatstone Bridge. Direct current from three dry cells could be changed in this way to alternating current by means of the induction coil and stepped up to a high pressure. This high pressure and very low current makes this method well adapted to measurement of resistance, because of the non-heating effect of the coils.

MEASUREMENTS OF RESISTANCE.

A set of unknown non-inductive resistances was obtained, and the apparatus set up, as shown in the diagram of connections for resistance measurements. A Post Office Box bridge (a modified form of the Wheatstone Bridge) was used, the resistances of which had been carefully calibrated. The zero method of measuring was adopted, the principle being, that, if the unknown resistance is exactly balanced by the bridge resistance, there will be no current in the galvanometer or telephone circuit. As the sensitiveness of this method is the object of this thesis, we will here explain what is meant by "per cent sensitiveness", by use of an example taken from the data. Take the resistance of coil #1. High reading was 305, low reading 304. That is, 305 and 304 gave equal noises in the receiver. Resistances 306 and 303 gave louder sounds

than either 304 or 305, so the zero point is somewhere between 304 and 305. The value of the resistance is 304.5 ±0.5. Now, if 0.5 is divided by the average, 304.5, the per cent sensitiveness is found. In this case the result is 0.16%. That is, 304.5 ohms is within 0.16% of the true resistance of the coil, and the per cent seisitiveness of this method for this coil is 0.16.

Now, one degree's rise in temperature will cause an error of 0.2% in the resistance of the coil; therefore, for measurements independent of temperature this method is well adapted.

RESULTS:

First: Several resistances were measured at random. The result was that, for high resistances, say above 100 ohms, this method gives quite accurate results. Referring to data-sheet #1, it will be seen that the per cent sensitiveness varies from 0.06 to 0.41 for very large resistances. This is very good, as all are within one-half of one per cent.

The same tests were made for small resistances, from 10 to 30 ohms. We used same induction coil as before (that is, the one with #12 primary.) In this case it was found that the per cent sensitiveness ranged from 1.5 to 10. Next, the same tests were made, using #38 wire coil, and results were better, but still not as good as for high resistances. In this last case, they ranged from 1.25 to 1.72%.

With more current from the vibrator coil better results could have been obtained for the lower range of resistances. There is no reason why, if we had had a number of transformations for the battery circuit, as good results could not have been obtained in the lower resistances as in the high ones.

CONCLUSIONS:

The data taken and the results derived therefrom show that this method is nearly as sensitive as the galvanometer, especially for high resistances, and, as has been above stated, it is believed that it is also accurate for low resistances.

The results have shown that the coil with finest wire on primary, lowest ratio of transformation, gives the best results.

Another important fact brought out by these experiments is that very much depends upon perfect contact of resistance plugs. The difference between the sound in the receiver, when the plug is in loosely, and when firmly placed, is very decidedly noticeable. In practice, this means greater accuracy with the telephone method than with the galvanometer method.

For very close readings where a reflecting galvanometer is used, the telephone method offers an excellent preliminary or approximate test, the galvanometer with its shunt removed

giving a delicate final reading. Not only would the time required for a complete measurement be reduced, assuming that prompt switching from telephone to galvanometer is possible, but also the small alternating current required for the telephone test will not have heated the coil appreciably. As a change of temperature of 1°F. produces a change of 0.2% in the resistance of copper, it is evident that the heating effect of a battery current used in galvanometer testing is not negligible.

Where an error of one-half of one per cent may be permitted, as in most practicable tests, we suggest the use of the telephone receiver and induction coil, in place of the galvanometer. This apparatus is cheaper, lighter, and can stand more hard knocks and rough handling.

CAPACITY MEASUREMENTS:

In the capacity measurements a number of paraffine condensers were used. The method of mixtures was employed. Direct current was used in these measurements, although with these condensers alternating currents of sixty frequency could be used. The condenser can be charged in 1/60 sec. For cable etc., it could not be used, for cable would not have time to charge. In fact, we cannot say that, using direct current and a time of 60 seconds, the cable is charged to its full extent. If cable were charged at several points in place of at one end this difficulty would be helped. The apparatus was set up as in diagram of connections for capacity measurements. The condensers were charged five seconds and then the charges mixed and discharged through induction coil and receiver. In these measurements the receiver gave a click or discharge. The capacity relations depend on the resistances used. One resistance was set at a given value and balance in charges obtained by changing the other resistance. It was found that for quite a range on the resistance no click was noticeable in receiver, thus denoting that the reading was rather indefinite and two readings were taken. These were taken at the highest point at which no click was heard and lowest point at which no click was heard. It was noted that capacity differed for different weather, being less on warm days than on wet, on account of leakage during wet weather.

RESULTS:

In this test several condensers were used with coil of #12 wire. The per cent sensitiveness while not as good as in case of resistance, was fairly good and accurate enough for many practical purposes. The range of sensitiveness (per cent) was from 0.26 to [illegible].25.

Same test was then made with coil of #38 wire and it was found that current was not completely discharged from the condenser. This fact was due to the high impedance of coil, making current leak out slowly and thus making discharge long and telephone click less sharp. #38 wire allowed only part of current to pass out at once, making noise in receiver weaker, and thus click weaker, and therefore sensitiveness less than with coil wire #12. #12 being a larger wire the current passed out through the coil at once, leaving no residual charge in condenser, and thus giving the receiver a clear, quick click.

CONCLUSIONS:

As shown in data, #38 wire cannot be used to advantage for the capacity measurements on account of high impedance of coil.

This method of measuring capacity, we admit, is not as quick or accurate as the deflection method of galvanometer, but at the same time, we think that for practical purposes and considering the cheapness and especially its portability,

it offers some advantages to the engineering world. The galvanometer for satisfactory capacity measurements requires a more delicate instrument than for resistance measurements. This fact shows that the portability of the instrument is the main point we have to offer for the telephone method.

GENERAL CONCLUSIONS:

We think that if the transformer coils and telephone receiver be substituted for galvanometer, both for measurement of resistance and capacity, the results would be accurate enough for most engineering purposes, and that the cost of said instruments would be much less. Surely a set for measuring resistance or capacity which can be roughly handled, set up almost anywhere, or in which no dark room is required, and one in which the results are fairly accurate, should find a place in the engineering world, and should supersede the present method for testing telegraph and telephone wire and cables.

While we are satisfied with the results obtained by telephone method in the measurement of resistances, we should like to say that there still remains much to be done in regard to investigation along the line of capacity measurement by this method.

DATA SHEET NO. I

RESISTANCE MEASUREMENTS TELEPHONE METHOD.

TEST NO.	HIGH R	LOW R	AVG. R	DIFF. ±	% SEN.
1	305	304	304.5	0.5	0.16
2	243	241	242	0.1	0.41
3	403	401.5	402.25	0.75	0.18
4	21.9	21.4	21.65	0.25	1.15
5	411.5	411.0	411.25	0.25	0.06
6	320.5	320.0	320.25	0.25	0.07
7	100.0	99.5	99.75	0.25	0.26
8	100.0	99.5	99.75	0.25	0.26

DATA SHEET NO. 2.

CAPACITY MEASUREMENTS. TELEPHONE MFT CO.

BOX NO.		R	HIGH R.	LOW R	HIGH C	LOW C	AVG. C	DIFF. ±	% SEN.	STAN C
10	1	2000	760	742	3.496	3.408	3.449	.036	1.4	1.295
	2	"	758	743	3.485	3.416	3.450	.0345	1.0	"
11	1	3000	1142	1136	3.419	3.401	3.41	.009	0.26	"
	2	"	1121	1105	3.515	3.465	3.49	.025	0.70	"
	3	"	753	738	3.509	3.439	3.479	.0347	1.00	"
3	1	2000	1958	1910	1.356	1.3227	1.339	.0165	1.24	"
	2	"	1992	1882	1.377	1.3002	1.3008	.0334	2.50	"
1	1	3000	3257	3205	1.2121	1.192	1.202	.01	0.91	"
	2	"	3045	3001	1.294	1.275	1.2845	.008	0.62	"

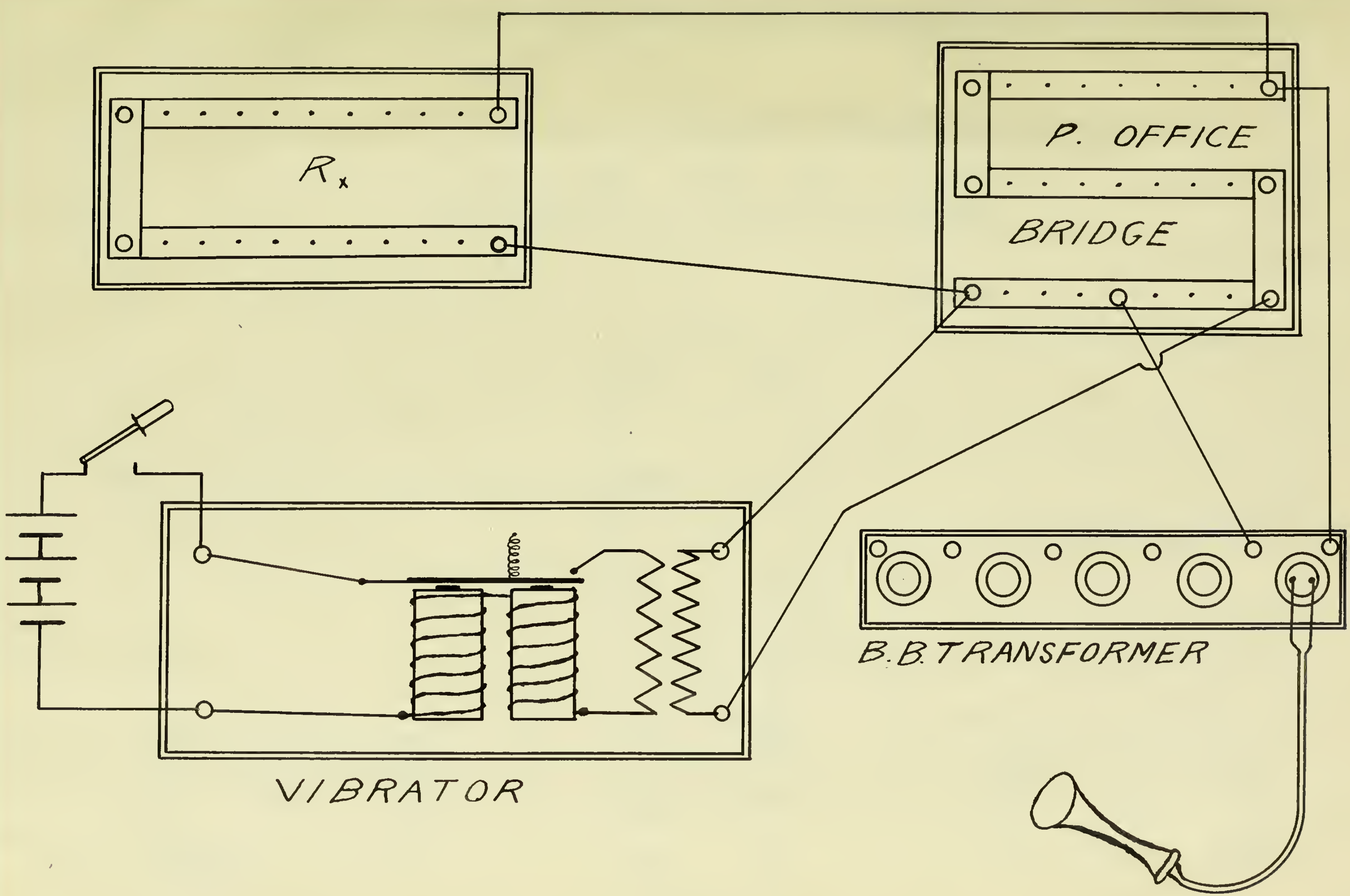
DATA SHEET NO. 3.

RESISTANCE MEASUREMENTS. GALVANOMETER [illegible].

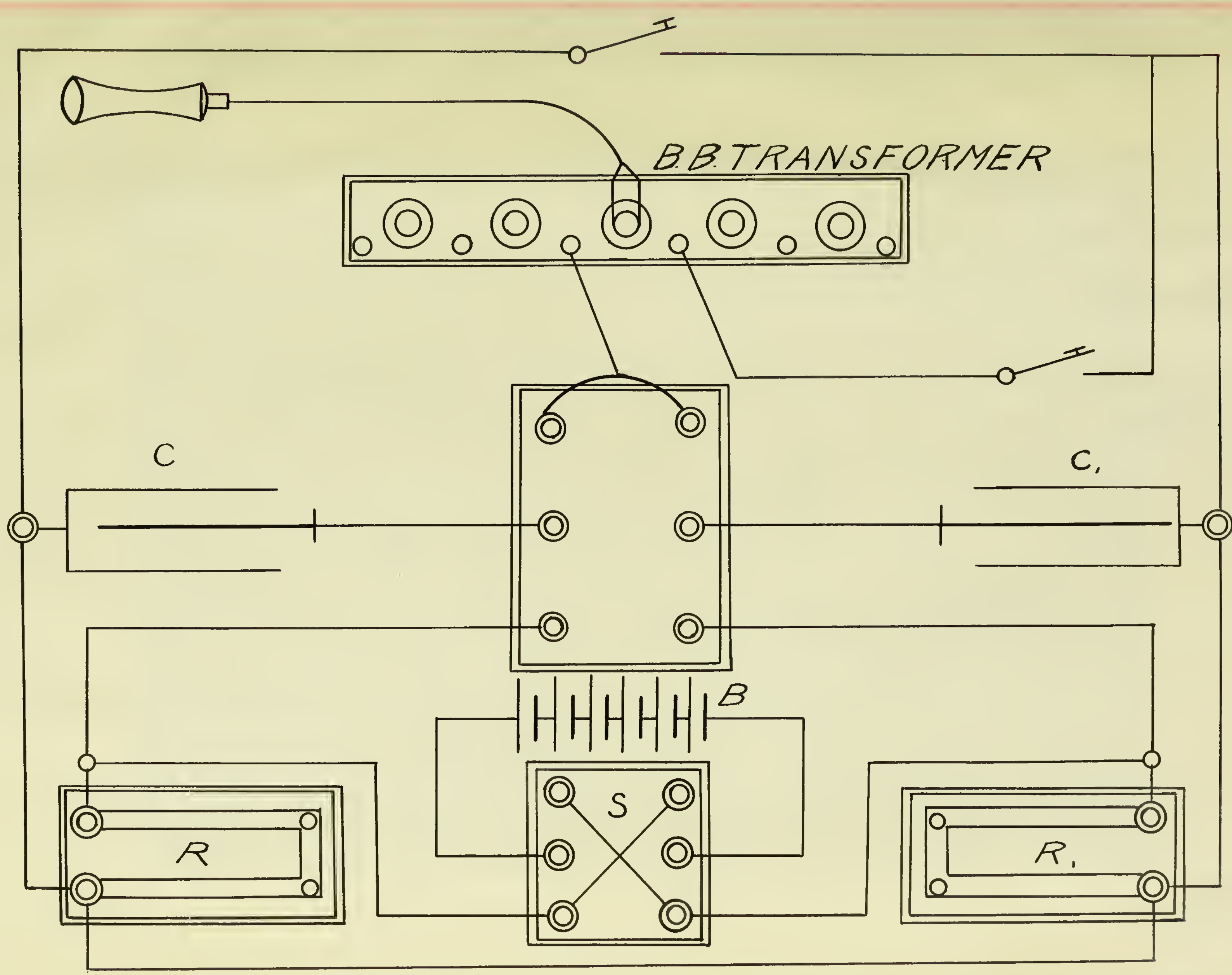
TEST NO.	HIGH R	LOW R	AVG. R	DIFF. ±	% SEN.
1	304.8	304.4	304.6	0.20	0.06
2	242.3	242.3	242.3	0.00	0.00
3	402.8	402.4	402.6	0.20	0.05
4	21.8	22.0	21.9	0.10	0.45
5	411.4	411.0	411.2	0.10	0.024
6	320.7	320.4	320.5	0.15	0.047

[illegible]

TEST NO.	COIL WIRE	HIGH R	LOW R	AVG. R	DIFF. ±	% SEN.
1	38	10.3	9.95	10.125	0.175	1.72
2	12	10.6	9.4	10.00	0.40	4.0
3	38	20.2	19.7	19.95	0.25	1.25
4	12	20.0	19.0	19.50	0.50	2.56



CONNECTIONS FOR RESISTANCE MEASUREMENTS



CONNECTIONS FOR CAPACITY MEASUREMENTS